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## RIGID AIR BARRIER ASSEMBLIES

### Introduction

Air barriers are required by the National Building Code to protect buildings against moisture damage due to air exfiltration or rain penetration and to control the interior climate and conserve energy. More knowledge of air barrier performance is needed to allow the design of air barrier systems to meet specific airtightness and structural resistance criteria.

This study was undertaken to familiarize designers and builders with a type of air barrier system made up of rigid panels applied to the walls. The objective was to produce a designer and builder guide to describe methods for installing rigid air barriers assemblies.

### Research Program

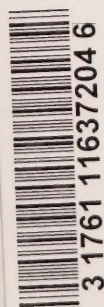
For the most part, the theoretical basis used to develop the concepts presented in the report were based on the results of a literature review of laboratory tests conducted on materials, either separately or in relatively simple assemblies. The concepts presented are also based on the author's experience in producing some 50 airtight buildings since 1982. Verification procedures undertaken on two of the author's buildings using infrared thermography are also described in the report.

### Results

Rigid air barrier systems are generally composed of three types of materials: rigid air barrier materials, sealing membranes and sealants.

The rigid air barrier materials must be sufficiently airtight and must be able to resist structural loads. Light concrete panels, plywood or water resistant gypsum board are suitable materials. Care must be taken to protect the gypsum board from rain during construction. Plywood has vapour retardent characteristics so it must also be used with caution to avoid creating a second vapour barrier on the cold side of the dew point. The method of fastening the rigid panels back to the building structure has been found to be crucial to the performance of the system. In one research project, seven of ten test samples failed to resist the structural loads, with most of the failures occurring at the fastening points. Typically-used fastener spacings are not adequate. For example, for gypsum board air barriers, a spacing of 200 mm along the studs and 150 mm at the bottom and top plates is recommended. Similar spacings are also recommended for light concrete panels and plywood, although specific test results for these materials are not available.

The ability of the system to resist building movement and air pressure differentials depends to a large degree on the joints between the panels. The joints must be designed and constructed to prevent airflow, to resist





any movement in the building, and to resist various air pressure differences. Where sealing membranes are used as the joint material, the main risk of failure has been shown to be due to separation from the substrate. Therefore, strips of fusible (torch-applied), self-sealing membrane are recommended for the joints between the rigid air barrier panels, as well as for the joints between these panels and other building components, such as windows. Self-adhesive membranes are not recommended except where it is impossible to use a torch for installation purposes without damaging adjacent components or where there is a danger of fire. To avoid separation, self-adhesive membranes must be well supported and they should not be installed when the temperature is below 10°C.

As the air barrier has to retain its effectiveness throughout the building's useful life, the use of applied sealants as components of the air barrier system should be limited in favour of membranes. Where there is no other choice, and sealants must be used, it is strongly recommended that the sealant be completely protected from the exterior elements.

The report presents typical cases to demonstrate the methods of installing rigid air barriers on four building types:

- Case 1: New building with concrete structure
- Case 2: Renovated building with concrete structure
- Case 3: New building with steel structure
- Case 4: New building with wood structure

The air barrier systems presented are designed to resist structural design loads of 1.0 kPa, with the exception of Case 3, which is designed to resist a structural load of 1.5 kPa.

The National Building Code recommends a maximum air permeability level of 0.15 L/s-m<sup>2</sup> at a 75 Pa pressure difference where the interior humidity is not expected to exceed 27% at an interior temperature of 21°C. For buildings with a humidity level between 27% and 55%, the maximum air permeability level is reduced to 0.10 L/s-m<sup>2</sup> and for buildings with an interior humidity level greater than 55%, the maximum rate is 0.05 L/s-m<sup>2</sup>. Cases 1 and 4 are designed for a maximum leakage rate of 0.10 L/s-m<sup>2</sup>, Case 2 is designed for a maximum leakage rate of 0.15 L/s-m<sup>2</sup> and Case 3 for a maximum leakage rate of 0.05 L/s-m<sup>2</sup>.

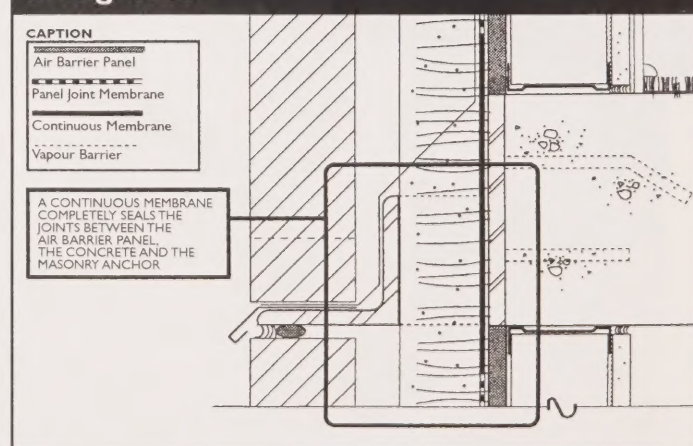
To verify the performance of the air barrier system, a three-stage verification system is recommended. The first stage is to verify the design using known performance of materials and systems and engineering calculations. The second stage is to conduct a mock-up of the air barrier system at the start of the job. This test would typically be conducted on site, allowing corrective measures to be easily undertaken if necessary, and would consist of air leakage testing and structural testing. The third stage is to conduct a thermographic survey of the building to identify areas of air leakage. The disadvantage of thermography is that it cannot be easily conducted during mild weather. However, it is possible to detect defects that would otherwise not be visible.

## Case 1 New Building with Concrete Structure

In this type of building, rigid panels of light concrete, plywood or waterproof gypsum are installed on the exterior of the building structure and the joints are sealed with membrane. Membrane strips at least 200 mm wide are recommended. Insulation is placed on the exterior of the rigid panels, taking care in the case of plywood to avoid a double vapour barrier.

Areas of concern with respect to maintaining the continuity of the air barrier system include the joint between the rigid panel and concrete slab edges (see Figure 1), shelf anchor locations, the roof/wall intersection, the joint with the foundation wall, and other penetrations, such as balcony slabs or windows. In such areas, it is important for designers to provide explicit details on the concept they are advocating to maintain the air barrier continuity.

**Figure 1: Continuity of Air Barrier along Slab**





A frequently observed defect in this type of system was open screw holes in panels. Often, screws are inserted in the wrong spots and then removed and reinserted in their proper locations leaving holes behind. While this error may seem harmless, in fact, the leakage through 60 screw holes is equivalent to the leakage through a 625 mm<sup>2</sup> hole, which is equivalent to the chimney effect for a two storey building. It is important to detect such holes before the insulation is installed and to patch them with a 200 mm x 200 mm fusible membrane. Sealants should not be used as pressure differences on the air barrier could cause them to separate from the surface.

### Case 2 Renovated Building with Concrete Structure

The concepts presented in this case are typical of renovation work on exterior walls and windows, where the existing siding, insulation and windows are removed. If concrete blocks are present in the existing structure, it may be possible to install a fusible membrane directly on the block. However, in the case presented, the back-up material was grooved terra cotta block, which due to the grooves, is unsuitable for the application of a membrane. Therefore, the application of rigid panels of waterproof gypsum board, plywood or light concrete panels is necessary.

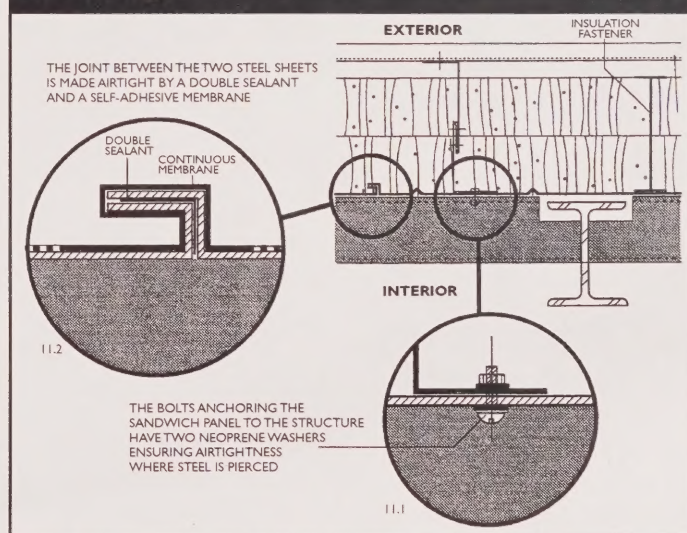
Areas of concern with respect to maintaining the continuity of the air barrier system are similar to Case 1. Mechanically fastening the membrane at the foundation wall can help ensure its adherence to a rough foundation wall. It is also recommended that at joints with a concrete column, rather than attempting to adhere 200 mm strips of membrane, the membrane be extended over the whole concrete column surface to avoid adherence problems that may occur with poured concrete.

As often occurs, in this sample case, no accessible window frame component provided sufficient adherence surface for the sealing membrane to avoid separation risk. In this case, a plywood enclosure was installed around the sides of the window rough opening. The joint between the plywood enclosure and the wall was sealed with a fusible membrane, while the joint between the aluminum window frame and the enclosure was sealed with a sealant on a joint backing. The sealant joint is protected from temperature extremes, ultraviolet rays and vandalism as it is covered with interior finish elements and exterior siding.

### Case 3 New Building with Steel Structure

In this case, the rigid air barrier material is a sandwich panel consisting of a steel facing coated on both sides with an anticorrosive material on the warm side, an insulating core of semi-rigid rock wool insulation, and an exterior pre-painted steel facing. The panels have an air infiltration and vapour transmission rate of nil. The particular areas of concern with this system are the joints between the panels. Neoprene washers are used where the steel is pierced for the anchor bolts. The raised joints between the panels are sealed with a double sealant and enveloped with a self-adhesive membrane (see Figure 2).

**Figure 2: Air Barrier Sandwich Panel, Continuity along its Joints and around Fastening Devices**



There was concern about using a fusible membrane at the panel joints as the heat produced by the blow torch might cause the pre-painted steel surface to peel or change colour. Fortunately, the joint membrane is located on the warm side of the wall where the membrane won't be exposed to extreme temperature variations. The insulation fastening devices are attached to the steel with an adhesive to avoid penetrating the steel.

Air sealing at intersections with other building elements is handled in a similar fashion as the other cases, using fusible membrane. The curtain wall employed in this case typically provides sufficient adherence surface for bonding of the sealing membrane.



## Case 4 New Building with Wood Structure

The case presented applies to a single-family house. Light concrete, plywood or water resistant gypsum board panels may be employed, similar to Case 1. An area of concern is the roof/wall intersection. The lower portion of the membrane used to seal the roof/wall intersection must be applied to the wall before the roof trusses are set in place to provide nail backing for the rigid roof air barrier. After the roof trusses and ceiling rigid air barrier panels are in place, the unattached portion of the joint membrane can be fastened to the ceiling air barrier material and all the joints in this material can be sealed. Care must also be taken to seal around penetrations, such as ducts or vents and to areas between heated and unheated spaces, such as garages.

## Implications for the Housing Industry

The report presents details for installing a rigid air barrier system. Many of these details have been proven in the field to be effective with respect to minimizing air leakage and sustaining the required structural loads. Further, they are expected to be durable and last the useful life of the building. Buildings can be expected to last much longer with fewer repair costs when air barriers are properly installed.

By following the installation methods demonstrated, building airtightness will improve. Further, as more designers require in situ tests, a better understanding of installed air barrier assemblies will be gained and it may become possible to predict with precision the performance of a whole range of air barrier assemblies.

**CMHC Project Manager:** Pierre-Michel Busque

**Research Report:** Rigid Air Barrier Assemblies

**Research Consultant:** Petrone Architects

A full report on this project is available from the Canadian Housing Information Centre at the address below.

## Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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